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# Effect of root-end resection and root-end filling on apical leakage in the presence of core-carrier root canal obturation

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## Abstract

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**Aim** To evaluate the apical seal of canals filled with a core-carrier obturator following root-end resection with and without a root-end filling.

**Methodology** Thirty single-rooted human teeth with single canals were used. Root canal treatment was performed and canals filled with a core-carrier obturation technique. The teeth were then randomly assigned to three groups ( $n = 10$ ). In the first group root canal filling only was performed. After orthograde filling, the teeth of the second group were resected apically, perpendicular to the major axis of the root. In the third group after apical resection, a root-end cavity was prepared using ultrasonic diamond retrotips and the cavities filled with Super-EBA cement. During a period of 3 h and with a headspace pressure of 0.12 atm, methylene-blue solution was forced through a

tube that was connected to the apical end of each tooth specimen. The coronal end of the tooth was connected to a capillary tube containing an air bubble. Leakage was evaluated by observing the distal displacement of the air bubble. The roots were then sectioned along their long axis. Using a stereomicroscope, linear dye infiltration at the dentine–cement interface was determined. Kruskal–Wallis and Mann–Whitney tests were used to compare the three groups.

**Results** Linear dye infiltration was significantly greater in root canals filled with the core-carrier obturators and resected apically ( $0.9 \pm 0.9$  mm) when compared with those that had root-end fillings ( $0.2 \pm 0.4$  mm). Air bubble displacement was not observed.

**Conclusion** Root-end filling improves the sealing of roots with core-carrier obturation following root-end resection.

**Keywords:** core-carrier obturation, microleakage, root-end filling, root-end preparation.

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## Introduction

Following thorough cleaning and shaping of the root canal system, complete filling of the root canal system is recommended for predictable success in root canal treatment (Schilder 1974). However, even with the best level of achievement, both coronal and periradicular leakage of fluids into the canal system can occur (Hovland & Dumsha 1985, Saunders & Saunders

1994). Generally, when this occurs nonsurgical root canal retreatment will eliminate the problem and success can ensue at a reasonably high level (Ruddle 1997, Lazarski *et al.* 2001). In some cases however, retreatment may require a surgical approach, at which time the cleaning and sealing of the apical portion of the root canal system is especially important (Gutmann & Pitt Ford 1993, Abramovitz *et al.* 2002).

The apical management of the resected root-end, i.e. root-end preparation and filling may be dictated by the nature of the filling in the root canal system. If the canal is filled with a paste or gutta-percha, root-end cavity preparation is straightforward and has been detailed by many authors (Gutmann & Harrison 1991).

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However, there is little in the literature that addresses the management of the resected root-end when a plastic core-carrier obturation is present. Furthermore, there is little indication as to the nature of the seal when a root with this type of canal filling is resected and whether or not the placement of a root-end filling is mandatory (Baker & Oguntebi 1990, Daugherty & Biggs 1998). There are indications that in the presence of a well filled canal, resection of gutta-percha alone may be sufficient with apical healing being limited to fibrous scar tissue as opposed to complete tissue regeneration (Gutmann & Harrison 1991).

Presently there are no clinical guidelines that indicate whether canals filled with a thermoplasticized core-carrier technique require a root-end filling subsequent to root-end resection.

The purpose of this study was to determine if following root-end resection on teeth filled with a thermoplasticized gutta-percha core-carrier technique, root-end preparation and root-end filling are necessary to ensure an apical seal.

## Materials and methods

### Selection of teeth

Thirty single rooted incisor and canine teeth were extracted from 25 subjects aged 18–45 years [mean  $30.8 \pm 8.5$  (SD) years], for orthodontic and/or periodontal reasons. All teeth were thoroughly cleaned and briefly placed in 5% sodium hypochlorite solution. The samples were then stored in 10% formalin.

None of the teeth contained restorations nor had been previously root filled. Root integrity was assessed and teeth having defects or fractures were excluded. Absence of anomalies in the root canal system was confirmed radiographically.

### Root canal treatment

Root canal treatment was performed on all teeth by a single operator. Canal preparation was completed using a crown-down technique, and nickel-titanium ProFile instruments (Dentsply Maillefer Instruments, Ballaigues, Switzerland). The instruments were mounted in a reduction handpiece with a 20 : 1 ratio (Kavo Dentale, Biberach, Germany) powered by an electric motor (TC Motor 3000; Nowag, Goldach, Switzerland) set at 300 r.p.m. All root canals were dried with paper points and then filled with a core-carrier obturator (Thermafil, Dentsply Maillefer) and root canal sealer (Pulp Canal

Sealer, Kerr, Orange, CA, USA) as follows. Verifiers (Dentsply Maillefer) were used to confirm the appropriate size for filling the canal. The length was marked on the Thermafil obturator. The latter was heated in the ThermaPrep oven (ThermaPrep Plus; Dentsply Maillefer) for the recommended time. Root canal sealer was mixed according to the manufacturer's instructions and the sealer placed into the canal by using a fine-medium master gutta-percha cone. The cone was coated with a thin, evenly distributed, layer of sealer that was applied twice to the walls of the root canal. The preheated Thermafil obturator was slowly positioned to working length in a single motion. Then, the plastic shaft was removed at the canal orifice with a stainless steel round bur (Therma-Cut 012; Dentsply Maillefer).

The samples were then assigned to one of three groups by means of a computer generated randomized table. Each group was composed of 10 teeth. In the first group, used as a control [root canal filling (RCF) group], only root canal treatment was performed; the teeth of this group were not sectioned. The teeth assigned to the second group [RCF + apical resection (AR) group] were resected apically 3 mm from the root apex at a 90° angle to the long axis of the root. To ensure roots were sectioned reproducibly, each tooth was inserted in a wax support where reference lines had been drawn. The section was made with a tungsten carbide straight fissure bur mounted on contra-angle, high-speed handpiece (Kavo Dentale, Biberach, Germany) and with constant water irrigation to avoid overheating.

In the third group [RCF + AR + root-end filling (REF) group] after performing root-end resection a root-end cavity was prepared. Initially, a cavity 3 mm deep was prepared, using a diamond type Res B retrotip EMS (EMS, Nyon, Switzerland) and a ultrasonic source P. M. 400 (EMS) set at half power. To ensure that all gutta-percha had been removed from the cavity and that the morphology of the canal had been preserved, radiographs of all roots were carefully examined by two independent evaluators. In case of disagreement the radiograph was re-evaluated jointly until a consensus was achieved. A cement based on zinc oxide-eugenol reinforced with the addition of benzoic acid and alumina (Super EBA; Harry J Bosworth Co., Skokie, IL, USA) was placed in the cavities using a microspatula and a microplugger (Hu-Friedy, Chicago, IL, USA).

### Leakage tests

The outer surface of each root was cleaned with a 17% EDTA solution buffered at pH 7.5 (Ogna Laboratori

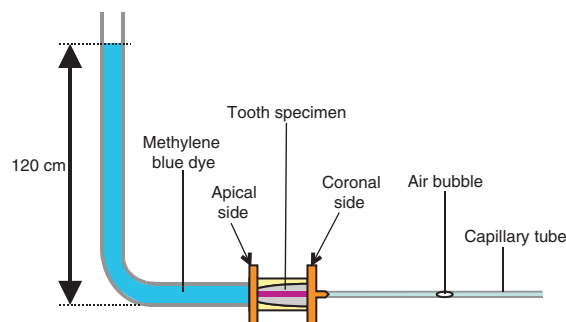
Farmaceutici, Muggiò, Milan, Italy) without contacting the EBA cement. The surface was then rinsed with saline solution and roots embedded in epoxy resin inside plastic cylinders having the same length as the samples. The crown and the apical regions were not embedded.

The samples were tested for leakage with methylene blue dye using a device (Fig. 1) similar to that described by Wu *et al.* (1993, 1994).

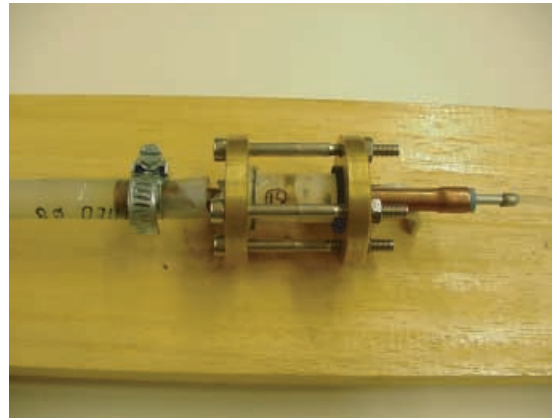
The cylinders containing the teeth were secured between two brass discs that were fixed by four screws (Fig. 2). The discs had a central hole to allow passage of dye through the sample. Furthermore, the brass discs were equipped with rubber surfaces, so that no liquid could escape between the disc surface and the plastic cylinder.

A plastic tube of 0.8 cm inner diameter was fixed to the apical portion of the tooth, through a thin metal pipe welded to the brass disc. Each tube was connected to the metal pipe via a metal ring secured with a screw. The tube was secured to a vertical holder and filled with 2% aqueous methylene blue dye solution at neutral pH up to 120 cm in height, so that a pressure of 0.12 atm was applied to the apical portion of the sample. Another plastic capillary tube 120 cm long was connected to the coronal surface of the tooth with the interposition of another thin metal pipe. The inner diameter of the latter tube was 1 mm. This tube was filled with water and fixed on a rest. An air bubble was then intentionally created inside the small tube, approximately at the half way position. A caliper with marks every millimetre was placed under the small tube to assess the movement of the air bubble. The free end of the capillary tube was left open, so that fluid distal to the air bubble could leak out.

The position of the air bubble was assessed 3 h after the circuit was filled (Wu *et al.* 1994).



**Figure 1** A drawing of the apparatus used for the infiltration test.



**Figure 2** The sample embedded in epoxy resin inside rigid plastic cylinder is fixed between two brass discs by four screws. Discs have a central hole allowing dye flow.

### Evaluation of dye leakage

At the end of the perfusion test, all teeth were sectioned in two halves along the length of the root, using a Isomet Low Speed Saw (Buehler, Lake Bluff, IL, USA). The longitudinal sections were examined with an optical stereomicroscope at 12× magnification (Wild M.P.S. 15-11 Stereomicroscope, Herrbrugg, Switzerland). The samples were evaluated independently by three examiners; blinding of the examiners was not possible. The linear dye penetration was measured from the sectioned root-end, by a graduated scale in the microscope (Bondra *et al.* 1989, Tuggle *et al.* 1989, Higa *et al.* 1994, Torabinejad *et al.* 1994, O'Connor *et al.* 1995). The greatest value recorded from the two tooth sections was taken into consideration for the statistical analysis. When discordant infiltration data were reported by the examiners (on two measurements), new examinations were repeated, and any further controversy was resolved by discussion. Pictures of the samples were also taken by a digital camera connected to the microscope.

The mean linear dye penetration within the three groups were statistically compared using the nonparametric Kruskal–Wallis test and the Mann–Whitney U-test.

### Results

Results of the leakage test are summarized in Table 1. The evaluation of linear dye penetration revealed that four of the teeth belonging to the RCF group and seven of the teeth belonging to the RCF + AR group had leaked,

**Table 1** Results of dye leakage evaluation in the three groups. Results are expressed in mm

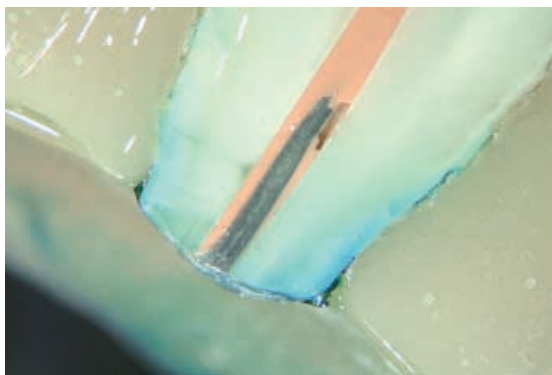
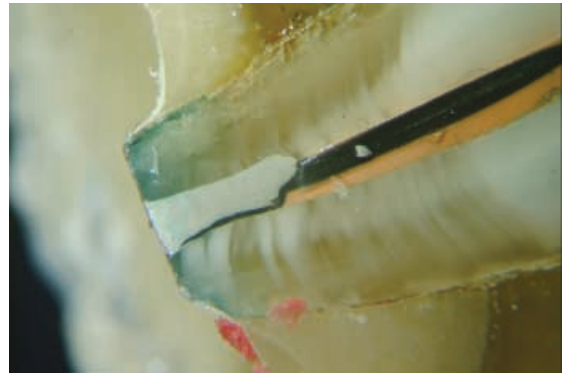
Sample no.	RCF only	RCF + AR	RCF + AR + REF
1	0.7	0.0	0.0
2	0.0	0.0	0.0
3	0.5	0.3	0.0
4	0.0	1.3	0.0
5	0.0	1.0	0.0
6	0.0	0.0	0.0
7	0.4	2.9	1.3
8	0.0	0.5	0.2
9	0.0	1.7	0.0
10	0.8	1.2	0.0
Mean	0.2	0.9	0.2
SD	0.3	0.9	0.4

RCF, root canal filling; AR, apical resection; REF, root-end filling.

the highest values being 0.8 and 2.9 mm, respectively. Among the teeth in the RCF + AR + REF group only two samples had leaked, in no instance greater than 1.3 mm. None of the samples showed fractures or presence of dye on the root-end cavity floor. Overall, leakage was greater in the roots that were simply resected ( $0.9 \pm 0.9$  mm), when compared either with those teeth that were root-end filled ( $0.2 \pm 0.4$  mm) or to those that were only filled ( $0.2 \pm 0.3$  mm).

The Kruskal–Wallis test demonstrated a significant difference between the three groups ( $P = 0.04$ ). The difference between the RCF + AR and the RCF + AR + REF groups was statistically significant when using the Mann–Whitney test ( $P < 0.03$ ).

Figure 3 shows a resected root belonging to the RCF + AR group; infiltration of the blue dye was 0.3 mm. Figure 4 shows a tooth belonging to RCF + AR + REF group; in this case infiltration was not detectable.

**Figure 3** Section of a resected root belonging to RCF + AR group. The 90° cut is visible. The extent of penetration of the blue dye was 0.3 mm.**Figure 4** Section of a resected root belonging to RCF + AR + REF group. In this sample penetration of the blue dye was not detectable.

Air bubble displacement was never observed, indicating absence of fluid movement into the capillary tube.

## Discussion

The experimental model described is similar to that used by Wu *et al.* (1993) except that the movement of blue dye (not that of water) was assessed by observing the displacement of an air bubble. At the same time, the present device was useful to detect linear dye infiltration at the filling–dentine interface.

In the present study the presence of the carrier did not hinder root-end cavity preparation. The carrier could be moved laterally, compressed against the walls of the canal and melted in the cavity giving adequate access to the gutta-percha. The retrotip insert was advanced perpendicular to the long axis of the root, alternating with gentle circular movements inside the canal lumen. As the activated insert can cause indentations or scratches on the dentine surface exposed after root-end resection, care was taken to activate the insert after its introduction in the cavity and deactivate it before withdrawal, thereby avoiding accidental contact between the root-end surface and the retrotip.

In the present study no bubble displacement was detected in any of the samples examined, reflecting no fluid movement through the apparatus. This would suggest that the seal had no gaps extending between the apical and coronal ends in all samples. Hence, when the result of fluid movement is used as an estimate of leakage, no difference among the three groups was detected. However, when the results of linear methylene blue dye penetration were evaluated,

a statistically significant difference was detected among the three groups. The dye penetration method in fact detected on average 0.2–0.9 mm cul-de-sacs (short voids), as shown in Table 1, suggesting that two different leakage measurement procedures may lead to completely different conclusions. Therefore, the results would suggest that the fluid movement method did not detect these cul-de-sacs voids. In fact, according to the Poiseuille's law, only when through and through voids exist could the air bubble move.

In the control group (RCF group), the mean dye penetration was 0.2 mm, reflecting a low infiltration. In the root-end resected group (RCF + AR) the mean dye penetration was higher than the control. This increase in infiltration might be related to a disruption of the material along the canal creating a pathway for leakage. In the group that was root-end filled (RCF + AR + REF) the mean dye penetration was similar to the control group. The root-end filling therefore improved the sealing ability of the root canal system.

A vacuum system was not used prior to testing apical dye penetration, as described by other authors (Goldman *et al.* 1989, Spångberg *et al.* 1989, Oliver & Abbott 1991, 2001). Vacuum systems remove entrapped air that may lead to failure of the experimental system to disclose all voids within the filled roots and then produce inaccurate results in leakage measurement procedure. However, despite the scientific evidence presented in these studies, other investigators continued to test apical leakage without using vacuum (Peters & Harrison 1992, Antonopoulos *et al.* 1998). Peters & Harrison (1992) compared the marginal apical leakage of several root-end filling materials. They observed statistically significant differences between dye penetration methods under vacuum (25 Torr) and nonvacuum conditions when intermediate restorative material was used as a root-end filling. However, no significant difference between the two dye penetration methods was observed when amalgam or orthograde gutta-percha with sealer were used as root-end filling. From the above studies one may conclude that the actual influence of vacuum systems in testing apical leakage has not yet been clearly shown.

## Conclusion

The results of the leakage tests demonstrated that root-end filling improves the sealing of roots with core-carrier obturation following root-end resection.

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